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INVESTIGATION ON STARTUP OF A SMALL HORIZONTAL AXIS WIND TURBINE

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ABSTRACT

Wind energy plays an important role in the power generation as the fossil fuels become more and more scarce and costly. Small horizontal axis wind turbine has been considered in this study and its problems are identified and analyzed. Magnetic locking and higher static friction are the main problems faced by small horizontal axis wind turbine at lower wind speeds. As for this study, the wind speed is considered at 4 m/s in accordance with the Indian average wind speed. The soft iron core is replaced by Aluminum core in order to minimize the problems such as higher weight, magnetic locking and higher static friction and their effects. Some of the problems have been solved with some drawbacks which will be solved by further investigations.

KEYWORDS: Wind HAWT, Wind Energy & Start-up of Wind Turbine

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Original Article

INTRODUCTION

Wind energy is certainly a vast, clear, safe and renewable green energy resource. Wind energy has become economically more viable in comparison to fossil fuels. The usage of wind energy can be dated back to the ancient times since mankind has been benefited from the power of wind. With the changing climates and growing environmental concerns, the need for a greener environment and atmosphere with cleaner energy has never had such an impact as today [1].

Wind power has become an important and integral source of environmental-friendly energy and its importance keep on increasing ever as never. Because of the tremendous need for power, the amount of wind power installed is increasing every year and many countries have shown interest to make large investments in wind power in near future [2]. The importance of wind energy is nothing further that wind energy requires no water in its operation, as in the case for the fossil fuel extractions and their usage and conversion of other energies to power do require water, which is more essential to sustaining life than to power production, except during maintenance cleaning which does not happen very often. Additionally, exhausts of wind power production don't produce any kind of poisonous pollutants such as nitrous oxide or sulfur dioxide or particulates as in the case of coal and gas to a lesser extent. The forecast by the International Energy Authority (IEA) to make the greatest contribution of all clean energy technologies in the coming decades in terms of $C0_2$ reduction, making wind power an invaluable asset in the quest for a sustainable environment [1].

A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machineries, such as a pump or grinding stones, the machine is usually called a Wind Mill. If the mechanical energy is then converted to electricity, the machine is called a Wind

Generator or a wind turbine. A vast kind of wind turbines is developed in due course [3] and put together they can be classified into two broad groups of turbines based on the orientation of their axis of rotation. The classifications fall as horizontal axis wind turbines (HAWTs) and vertical axis wind turbines (VAWTs) [2].

Horizontal-axis wind turbines (HAWTs) have the main rotor shaft and electrical generator at the top of a tower and must be pointed into the wind an example of which is shown in figure 1. Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically an example of which is shown in figure 2.

Figure 1: Horizontal-Axis Wind Turbine.

Figure 2: Vertical-Axis Wind Turbine.

Wind availability, the ainfluence of height of installation above ground, an effect of wind gusting and micro-siting of wind turbines are the main factors to be considered while selecting the site for the annual energy output. Site selection, height, choice of wind generators, a velocity of wind, wind power potential are considered as the primary objective functions of mathematical probabilistic models to predict or determine the wind turbine energy output [4]. Small wind turbines operating face some problems often if not regularly resulting in the poor performance due to the low Reynolds number (Re) in the wind, which is a result of low wind speeds and small rotor size. The rotor involved an exponential twist, taper distribution and the AF300 airfoil for improved aerodynamic performance even at lower wind speeds say 3-7 m/s [5]. Energy is one of the user parameters in wind power generation since it gives different conditions for wind power generations with a single unified metric. With the help of these energy methods, better, site selection and better turbine design leading to improved system efficiency decreased economic cost and increased wind energy system capacity [6]. The magnitude of power loss, increase with a decrease in wind speeds [7]. When in close proximity to the seabed, the wake deflects downwards due to mass flow rate discontinuity above and below the rotor disk [8]. The focus should be given on the research towards the improvement of characteristics of a rotor for the betterment of power generation through wind [9].

To extract the maximum possible power from the available, the blades should be rotating at wind speed at a velocity lower than its average wind speed and starting torque near the hub also contributes to the start of the rotation of the blade [10].

Magnetic locking and higher static friction are found to be the major problems for initial start-up of small horizontal axis wind turbines at lower wind speed. An effort is taken in order to design a small horizontal axis wind turbine by avoiding the initial startup problems.

METHODOLOGY

Blades, rotor, stator, towers, generators form the major components of the horizontal axis wind turbine. The design is based on the Betz limit which is that the maximum achievable energy of a wind turbine. The basic law for the wind turbine is Faraday's law which states that "It says that when a conductor is placed in a rotating magnetic field it experiences a current". The experiment is performed as a comparison of two small horizontal axis wind turbine one of which has a soft iron core and another has an aluminum core with same dimensions. Here aluminum is considered as the base material instead of iron because of its high strength to weight ratio. The rotor is designed with the following specifications.

Outer Diameter: 166mm

Inner Diameter: 131mm

Widthof permanent magnets: 41.5 mm

Heightof permanent magnets: 73.4 mm

Number of permanent magnets: 10

The stator is placed in the rotating magnetic field and the magnetic flux lines are cut by the iron stamps of the stator with inclined slots ins which the coils are wound and they are coated with varnish in order to avoid the atmospheric effects. The stator design specifications are

Diameter: 130mm

Core length: 77mm

Number of bearings: 2

Shaft outer diameter: 52mm

Shaft inner diameter: 42mm

Number of slots : 30

The Specifications for Coil Winding in Iron Stampings are as Follows

Coil: 20 gauge insulated copper wire

Winding : 40 turns per slots

Type of connection: 3-phase star connection

Pitch : 1 to 4

The looping pattern: N---1-4-7-10-13-16-19-22-25-28-R

N---2-5-8-11-14-17-20-23-26-29-Y

N---3-6-9-12-15-18-21-24-27-30-B

The main shaft is made with 52 and 47 mm outer and inner diameter respectively with two SKF6204 bearings.

In case of aluminum stator stamps were not made, but instead, a whole block of aluminum is machined to the required specifications with the slots prepared by drilling and metal cutting. The other major difference in the two stators is the winding. Aluminum stator is wounded with the same 20 gauge coils, but with 72 turns per slot whereas in iron stator only 40 turns per slot were used. This increase the amount of magnetic conductivity of the setup since aluminum does not have a higher permeability like iron. Both the experimental set up is placed on the top of the building for measurement of power which is shown in figure 3.

Figure 3: Working Horizontal-Axis Wind Turbine

RESULTS AND DISCUSSIONS

Before the setup is installed in the destination, a Pro-E model is created with the available specifications and assembled and then animated to see that if this project works really which is shown in figure 4. This Pro-E model was a successful step and only after this process the real Small horizontal axis wind turbine was installed. The wind speed in the spot was around 3m/s to 6 m/s.

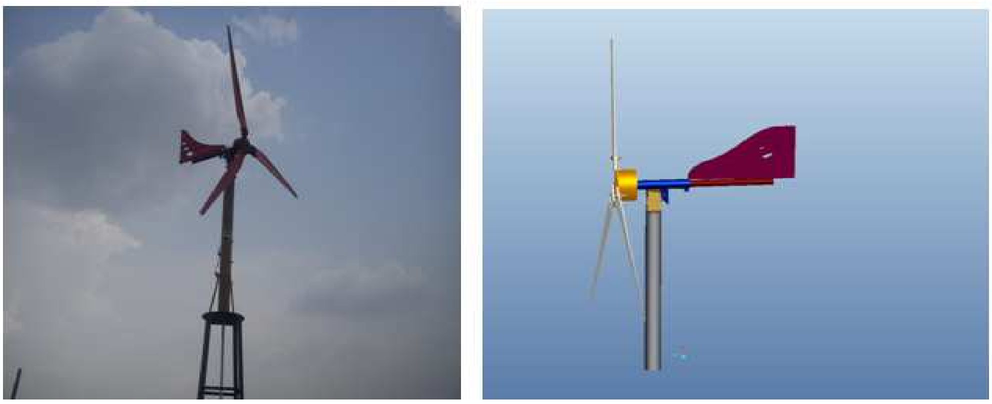

Figure 4: Assembly Design

The wind turbine model with the iron stator did not show initial rotation when the wind speed was around 3m/s. This is due to the magnetic locking force and the higher static friction. The wind speed of 3m/s was not enough to give the

initial motion by breaking the magnetic force of attraction between the stator and the rotor. Also, the higher static friction supported to the locking of the stator and the rotor. But when the wind speed crossed 4m/s the wind turbine blades started to rotate. This is because a wind speed of 4m/s has given enough counter force to break the magnetic locking which prevents the rotation of the blades. When the wind speed was around 5m/s a power of about 400W was obtained, but with a lower wind speed no rotation was found.

The wind turbine model with the aluminum stator has shown initial rotation even when the wind speed was around 2m/s. This is due to the reduced weight of the stator due to aluminum and magnetic locking was not much a factor to be worried in this case. The blades do show a positive result of rotating even with a lower wind speed, but power was not generated due to the lesser permeability of aluminum.

CONCLUSIONS

This experiment provides the method to validate the production of power from wind energy when the wind blows at less than 2m/s. Instead of using ferrous material inside the core of the horizontal axis windmill, aluminum, which is a conducting material is used. Even though there was no power produced, the wind turbine blades rotated even at a lower wind speed which is a positive outcome. Weight reduction was one of the notable outcomes of this experiment and with better alternative stator materials Power at a lower wind speed can be achieved without changing much of the design parameters.

RESEARCH LIMITATION

This work was done in the private small -scale industry located at Coimbatore, Tamilnadu, India. The size which is taken as a sample of this project work was limited to a small HAWT which was already there in the industry. So these results can be improved by using improved design parameters.

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REFERENCES

1. *N. A. Ahmed and M. Cameron, (2014), "The challenges and possible solutions of horizontal axis wind turbines as a clean energy solution for the future," Renewable and Sustainable Energy Reviews, vol. 38, pp. 439-460.*
2. *S. Eriksson, H. Bernhoff, and M. Leijon,(2008), "Evaluation of different turbine concepts for wind power," Renewable and Sustainable Energy Reviews, vol. 12, pp. 1419-1434.*
3. *P. W. Carlin, A. S. Laxson, and E. Muljadi, (2003), "The history and state of the art of variable-speed wind turbine technology," Wind Energy, vol. 6, pp. 129-159.*
4. *G. J. Herbert, S. Iniyan, E. Sreevalsan, and S. Rajapandian, (2007), "A review of wind energy technologies," Renewable and sustainable energy Reviews, vol. 11, pp. 1117-1145.*
5. *R. K. Singh and M. R. Ahmed,(2013), "Blade design and performance testing of a small wind turbine rotor for low wind speed applications," Renewable Energy, vol. 50, pp. 812-819.*

6. *K. Pope, I. Dincer, and G. Naterer,(2010), "Energy and exergy efficiency comparison of horizontal and vertical axis wind turbines," Renewable Energy, vol. 35, pp. 2102-2113.*

7. *Ashwani Sharma & M. A. Murtaza, Modeling and Finite Element Analysis of Vertical Axis Wind Turbine Rotor Configurations, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 6, Issue 3, May- June 2016, pp. 23-34*

8. *A. M. Abdelsalam, K. Boopathi, S. Gomathinayagam, S. H. K. Kumar, and V. Ramalingam, (2014), "Experimental and numerical studies on the wake behavior of a horizontal axis wind turbine," Journal of Wind Engineering and Industrial Aerodynamics, vol. 128, pp. 54-65.*

9. *A. Bahaj, L. Myers, R. Rawlinson-Smith, and M. Thomson,(2012), "The effect of boundary proximity upon the wake structure of horizontal axis marine current turbines," Journal of Offshore Mechanics and Arctic Engineering, vol. 134, p. 021104.*

10. *J. P. Monteiro, M. R. Silvestre, H. Piggott, and J. C. André, (2013), "Wind tunnel testing of a horizontal axis wind turbine rotor and comparison with simulations from two Blade Element Momentum codes," Journal of Wind Engineering and Industrial Aerodynamics, vol. 123, pp. 99-106.*

11. *A. Wright and D. Wood, (2004), "The starting and low wind speed behaviour of a small horizontal axis wind turbine," Journal of Wind Engineering and Industrial Aerodynamics, vol. 92, pp. 1265-1279.*

12. *S.C. Prasanna, C. Ramesh, R. Manivel, M. Karthe ‘’ Tracking of optimal thermal and electrical power in solar PVT systems ” Pakistan Journal of Biotechnology Vol. 14 special issue Pp. 155- 159 (2017)*